

WHAT IS CLAIMED IS:

1. A method of controlling bandwidth usage by a group of connections in a communication network, the group of connections having an assigned group bandwidth, the connections in the group having respective minimum bandwidths providable within the assigned group bandwidth and respective current bandwidths that the connections are currently allowed to use, the method comprising the steps of:

- (a) calculating a total current bandwidth by adding up the current bandwidths of the connections in the group;
- (b) calculating a difference by subtracting the total current bandwidth from the assigned group bandwidth;
- (c) calculating an explicit rate for one connection in the group by adding said difference to the connection's current bandwidth;
- (d) determining which connections in the group are currently active;
- (e) calculating a sum of the minimum bandwidths of the active connections in the group;
- (f) using said sum to calculate a minimum explicit rate for said one connection;
- (g) altering said explicit rate to said minimum explicit rate under certain conditions; and
- (h) controlling the current bandwidth of said one connection according to said explicit rate.

2. The method of claim 1, wherein said step (g) includes altering the explicit rate to the minimum explicit rate if the explicit rate is less than the minimum explicit rate.

3. The method of claim 1, wherein said step (g) includes altering the explicit rate to the minimum explicit rate if

said difference is negative.

4. The method of claim 1, wherein said step (f) includes the further step of dividing the minimum bandwidth of said one connection by said sum, thereby obtaining a quotient.

5. The method of claim 4, wherein said step (f) includes the further step of multiplying the assigned group bandwidth by said quotient.

6. The method of claim 1, wherein the minimum explicit rate is calculated in said step (f) in one way if said one connection is active and another way if said one connection is inactive.

7. The method of claim 1, wherein the sum used in said step (f) includes the minimum bandwidth of said one connection, even if said one connection is currently inactive.

8. A cell receiving apparatus in a communication network supporting communication by transmission of cells on a group of connections, the group having an assigned group bandwidth, the connections in the group having respective minimum bandwidths providable within the assigned group bandwidth and respective current bandwidths that the connections are currently allowed to use, the cell receiving apparatus including:

an explicit rate calculation unit that receives information indicating the current bandwidths of the connections, calculates a total current bandwidth by adding up the current bandwidths of the connections in the group, subtracts the total current bandwidth from the assigned group bandwidth to obtain a difference, adds the difference

to each connection's current bandwidth to obtain an explicit rate for each connection in the group, determines which connections in the group are currently active, calculates a sum of minimum bandwidths of active connections in the group, uses said sum to calculate a minimum explicit rate for each connection in the group, and alters the explicit rate to the minimum explicit rate under certain conditions;

wherein the explicit rate of each connection in the group is used to control the current bandwidth of the connection.

9. The cell receiving apparatus of claim 8, wherein the explicit rate calculation unit alters the explicit rate to the minimum explicit rate if the explicit rate is less than the minimum explicit rate.

10. The cell receiving apparatus of claim 8, wherein the explicit rate calculation unit alters the explicit rate to the minimum explicit rate if said difference is negative.

11. The cell receiving apparatus of claim 8, wherein in calculating the minimum explicit rate of each said connection, the explicit rate calculation unit divides the connection's minimum bandwidth by said sum, thereby obtaining a quotient.

12. The cell receiving apparatus of claim 11, wherein in calculating the minimum explicit rate of each said connection, the explicit rate calculation unit multiplies the assigned group bandwidth by said quotient.

13. The cell receiving apparatus of claim 8, wherein the explicit rate calculation unit calculates the minimum explicit rate of active connections in one way and

calculates the minimum explicit rate of inactive connections in another way.

14. The cell receiving apparatus of claim 8, wherein said sum includes the minimum bandwidth of the connection for which the minimum explicit rate is being calculated, even if the connection is currently inactive.

15. The cell receiving apparatus of claim 8, further comprising a traffic shaping unit that enqueues cells belonging to a plurality of groups of connections in a single queue, each group of connections in the plurality of groups having its own assigned group bandwidth, the explicit rate calculation unit calculating explicit rates for the connections in each group separately.

16. A traffic control system comprising:
the cell receiving apparatus of claim 8; and
a cell transmitting apparatus that transmits cells to the cell receiving apparatus on each connection in said group in accordance with the explicit rate calculated by the explicit rate calculation unit.

17. The traffic control system of claim 16, further comprising a switching apparatus disposed between the cell transmitting apparatus and the cell receiving apparatus.

18. The traffic control system of claim 17, wherein the cell transmitting apparatus functions as an input line interface for the switching apparatus, and the cell receiving apparatus functions as an output line interface for the switching apparatus.

19. A method of controlling bandwidth usage by a group of

connections in a communication network, the group of connections having an assigned group bandwidth, the connections in the group having respective minimum bandwidths providable within the assigned group bandwidth and respective current bandwidths that the connections are currently allowed to use, the method comprising the steps of:

- (a) calculating a total current bandwidth by adding up the current bandwidths of the connections in the group;
- (b) calculating a difference by subtracting the total current bandwidth from the assigned group bandwidth;
- (c) calculating an explicit rate for one connection in the group by adding said difference to the connection's current bandwidth;
- (d) calculating a minimum explicit rate for said one connection;
- (e) altering said explicit rate to said minimum explicit rate if said difference is negative; and
- (f) controlling the current bandwidth of said one connection according to said explicit rate.

20. The method of claim 19, further including the step of altering the explicit rate to the minimum explicit rate if the explicit rate is less than the minimum explicit rate.

21. The method of claim 20, wherein said step (d) includes determining which connections in the group are currently active.

22. The method of claim 21, wherein the minimum explicit rate is calculated in said step (d) in one way if said one connection is active and another way if said one connection is inactive.

23. The method of claim 21, wherein said step (d) further includes the steps of:

calculating a sum of the minimum bandwidths of the active connections in the group;

dividing the minimum bandwidth of said one connection by said sum, thereby obtaining a quotient; and

multiplying the assigned group bandwidth by said quotient.

24. The method of claim 23, wherein said sum includes the minimum bandwidth of said one connection, even if said one connection is currently inactive.

25. A cell receiving apparatus in a communication network supporting communication by transmission of cells on a group of connections, the group having an assigned group bandwidth, the connections in the group having respective minimum bandwidths providable within the assigned group bandwidth and respective current bandwidths that the connections are currently allowed to use, the cell receiving apparatus including:

an explicit rate calculation unit that receives the current bandwidths of the connections, calculates a total current bandwidth by adding up the current bandwidths of the connections in the group, subtracts the total current bandwidth from the assigned group bandwidth to obtain a difference, adds the difference to each connection's current bandwidth to obtain an explicit rate for each connection in the group, calculates a minimum explicit rate for each connection in the group, and alters the explicit rate to the minimum explicit rate if said difference is negative;

wherein the explicit rate of each connection in the group is used to control the current bandwidth of the connection.

26. The cell receiving apparatus of claim 25, wherein the explicit rate calculation unit also alters the explicit rate to the minimum explicit rate if the explicit rate is less than the minimum explicit rate.

27. The cell receiving apparatus of claim 26, wherein the explicit rate calculation unit determines which connections in the group are currently active.

28. The cell receiving apparatus of claim 27, wherein the explicit rate calculation unit calculates the minimum explicit rate of active connections in one way and calculates the minimum explicit rate of inactive connections in another way.

29. The cell receiving apparatus of claim 27, wherein the explicit rate calculation unit calculates a sum of the minimum bandwidths of the active connections in the group, divides each connection's minimum bandwidth by said sum, thereby obtaining a quotient, and multiplies the assigned group bandwidth by the quotient to obtain the minimum explicit rate of the connection.

30. The cell receiving apparatus of claim 29, wherein said sum includes the minimum bandwidth of the connection for which the minimum explicit rate is being calculated, even if the connection is currently inactive.

31. The cell receiving apparatus of claim 25, further comprising a traffic shaping unit that enqueues cells belonging to a plurality of groups of connections in a single queue, each group of connections in the plurality of groups having its own assigned group bandwidth, the explicit

rate calculation unit calculating explicit rates for the connections in each group separately.

32. A traffic control system comprising:

the cell receiving apparatus of claim 25; and

a cell transmitting apparatus that transmits cells to the cell receiving apparatus on each connection in said group in accordance with the explicit rate calculated by the explicit rate calculation unit.

33. The traffic control system of claim 32, further comprising a switching apparatus disposed between the cell transmitting apparatus and the cell receiving apparatus.

34. The traffic control system of claim 33, wherein the cell transmitting apparatus functions as an input line interface for the switching apparatus, and the cell receiving apparatus functions as an input line interface for the switching apparatus.

09076918-061101